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Automatic detection of exudates for grading of macular edema in retinal fundus images

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Abstract

Macular edema is one of the retinal variations from the norm which influence the vision of the individual and prompts visual deficiency torn up pretty bad. In this paper a completely robotized strategy is proposed for the early discovery of macular edema in retinal fundus pictures. At first, the anatomic structures of retinal picture, for example, vessel, optic disc and fovea are identified. At that point the exudates which are available in the fovea part are distinguished for reviewing macular edema. The proposed technique was assessed on the two openly accessible DRIVE and STARE databases.

Keywords: Diabetic Macular Edema, Exudates detection, Retinal image processing.

1. Introduction

The darkest part on the focal part of retinal fundus picture is called macula (Figure 1(a)). The fovea (focus of macula locale) is liable for clear, sharp and itemized vision, when this part is influenced in diabetic patients; it prompts diabetic macular edema (DME) [1]. The DME pathophysiology begins with diminished retinal oxygen strain that shows as retinal vessel hyper penetrability and expanded intravascular pressure [2]. Exudates are the bright lesion which is framed by the spillage of proteins and lipids from the circulatory system into the retina by means of harmed veins [3]. Non-Clinically Significant Macular Edema (non-CSME) is an initial stage of edema where the areas of exudates are a good ways off from fovea and the focal vision isn't influenced (Figure 1(b)). Yet, in Clinically Significant Macular Edema (CSME) the exudates kept near or on the fovea and influencing the focal vision of the eye (Figure. 1(c)) [4].

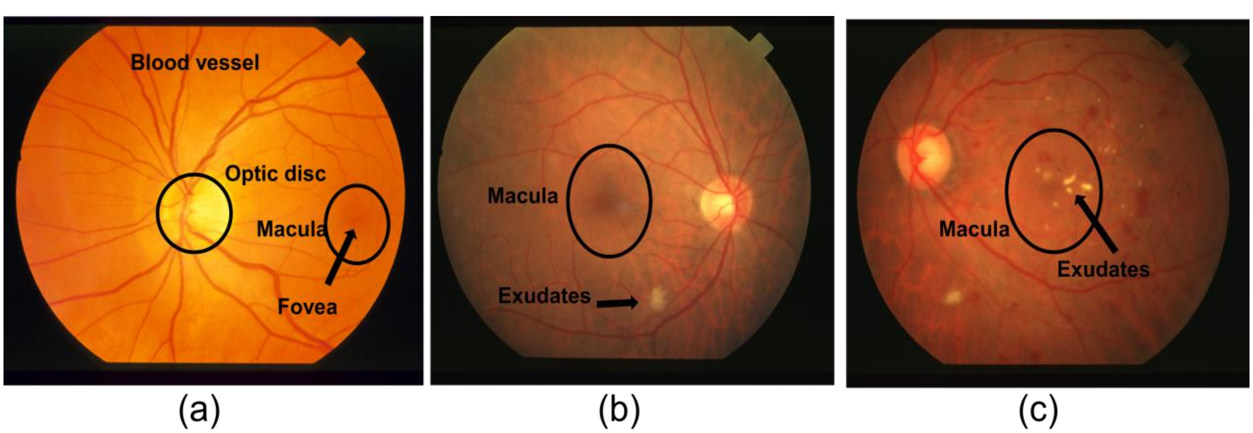

Figure.1. Retinal fundus images with various features

(a) Anatomical structure of retinal fundus image (b) Exudates image (non-CSME) (c) Exudates image (CSME image)

The presence of CSME is a significant sign for the commencement of appropriate treatment. The enormous and developing number of diabetic patients and expenses of current recognition strategies is an obstruction to accomplishing the suggested screening consistency. Hence the computerized confinement of anatomical structure and exudates is critical to develop a PC supported indicative framework for identifying DME. This paper presents a robotized calculation for macular edema identification in retinal pictures. In this work, first the principle segments of the human retina, for example, vessel, optic disc (OD) and fovea are identified. At that point the exudates competitors are separated utilizing OTSU strategy. In view of the presence of exudates pixel in different area it is evaluated as CSME, non-CSME or Healthy one. The commitment of this work is that it proposes a quick and powerful calculation that is equipped for identifying macular edema in beginning phase with better exactness. The productivity of the calculation is expanded by utilizing exudates identification just on fovea region. The exploratory outcomes are accounted for on two flexibly available DRIVE which means Digital Retinal Images for Vessel Extraction [5] and STARE which is abbreviated as Structural Analysis of Retina [6] databases.

The rest of the part of this paper is sorted out as follows: Section 2 quickly surveys the past work on exudates discovery. Segment 3 subtleties the proposed approach. Exploratory outcomes are accounted for and examined in Section 4. Area 5 closes the paper.

2. Related work

DME is a late period of diabetic eye disease that is portrayed by hard exudates testimony in fovea area, and resultant vision incident [7]. The vast majority of the scientists utilize mathematical morphology and classification is the method for exudates division. Walter et al. [8] uses morphological closing to take out vessels, and morphological reconstruction to find the states of the exudates. Sopharak et al. wipe out similar area of exudates by applying morphological tasks and fragment the exudates using thresholding [9] and fuzzy c-means clustering [10]. An active contour based procedure is proposed by Balazs et al. [11]. Morphological operations are employed on the enhanced image for candidate selection then the exudates are distinguished by a region wise classifier. An AI based methodology proposed by Sopharak et al. [12] distinguish exudates, they use Naive–Bayes classifier to group the pixel as ordinary or exudates. By combining Gaussian mixture model and support vector machine Akram et al. [13] improve the accuracy of exudates segmentation. Niemeijer et al. [14] utilize a K nearest neighbor (knn) classifier for fragmenting exudates pixels. The fragmented pixels are gathered into bunch and the groups are named as exudates. A straightforward strategy for division of hard exudates and soft exudates is proposed by Cemal Hose et al. [15]. They utilize reverse segmentation method to quantify and catch up the degeneration in retinal fundus pictures. They separate the retinal picture into high and low intensity picture for distinguishing hard and soft exudates. Jaafar et al. [16] Splits the pictures into disjoint areas first, and merge them dependent on nearby change. At that point they segment the exudates part by applying adaptive thresholding. Acharya et al. [17] extract the features in higher order spectra and apply support vector machine classifier for the segmentation of exudates parts. Siddalingaswamy et al. [18] find the macula area, and segment the hard exudates using clustering strategies for reviewing DME.

3. Proposed method

A two stage robotized technique is proposed in this work. In the primary stage, the retinal features, for example, vessels, OD and the fovea are identified. The discovery of fovea is significant for evaluating of macular edema and the fovea is located by utilizing vessel and OD properties. At that point in the subsequent stage, the exudates are distinguished in the fovea locale and reviewed as CSME or non-CSME.

The Contrast Limited Adaptive Histogram Equalization (CLAHE) technique is utilized on the green channel picture for upgrading the differentiation of the anatomical structure of the retinal picture. For enhancing the blood vessel the 2 Dimensional Gabor matched filtering is applied on the CLAHE'd output then thresholding strategy is employed to obtain the final vessel output. For localizing OD center and fovea, the candidate regions are identified using thresholding, then the area, density and distance conditions are employed to select the choose the last contestant and the presence of vessel is used to finalize the OD and fovea. In the subsequent stage, the exudates candidates are extracted using Otsu technique. Based the presence of exudates pixel in different locale it is reviewed as CSME, non-CSME or Healthy one. The flowchart of the proposed strategy is portrayed in Figure.2.

3.1 Blood vessel extraction

Vessel extraction is finished utilizing our before proposed strategy given in [19]. The difference among background and vessel is higher in green channel of RF picture; in this way the green component of the RF picture is extracted and utilized for the process. So as to stifle the impact of exudates and optic disc in the vessel division, the histogram equalization is utilized. Since the RF pictures have distinctive bright and dark locales, the CLAHE strategy is utilized to expand the differentiation of the vessel. The vessels are mathematically connected to Gabor reaction; along these lines an adjusted Gabor filter is applied in 12 distinct ways to upgrade the vessel from the enhanced picture. The multiscale Gabor channel portion is communicated as,

$$g_{\theta,s}(x,y) = exp\left\{-\pi\left[\frac{{x_p}^2}{(s\sigma_x)^2} + \frac{{y_p}^2}{(s\sigma_y)^2}\right]\right\} cos(2\pi f x_p) \quad (1)$$

where,

$$x_p = xcos\theta + ysin\theta \,;\; y_p = -xsin\theta + ycos\theta \quad (2)$$

θ –direction of the filter;
s – scale factor;
σ – standard deviation of Gaussian;
f – the frequency of cosine wave.

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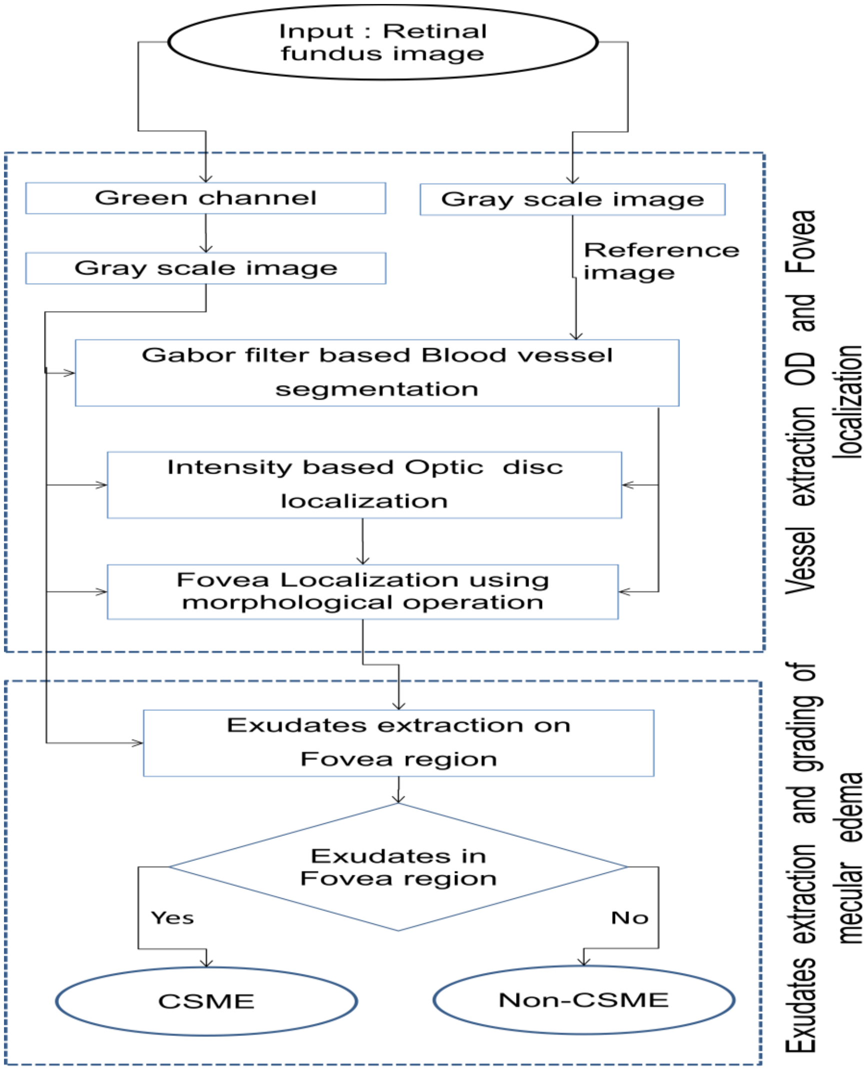

Figure2. Flow chart of proposed macular edema grading system

After the vessel enhancement, the entropy-based thresholding is employed to extract the blood vessels, finally the unconnected region is eliminated by applying suitable filtering. The output of the various stages of this process is shown in the Figure.3.

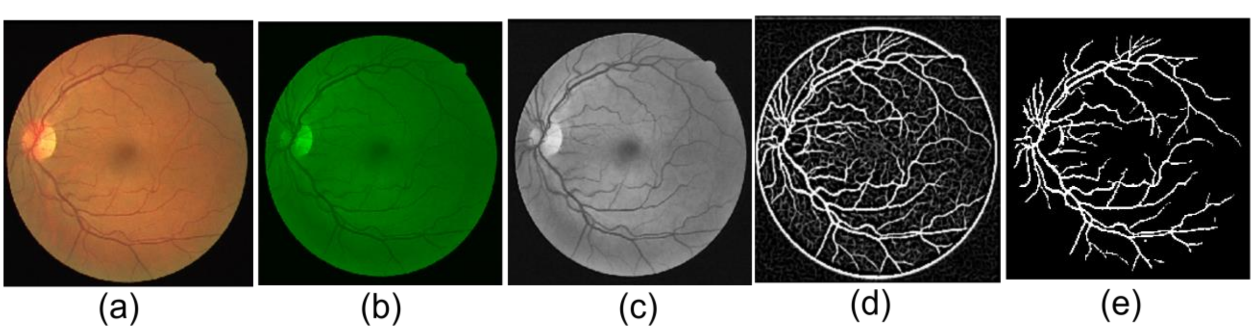

Figure.3. Extraction of blood vessel

(a) Color fundus image (image 1of DRIVE) (b) image with green component
(c) Enhanced green component image (d) Enhanced blood vessel image
(e) Extracted blood vessel

3.2 OD center localization

OD is the round and bright spot in the retina. The discovery of OD is significant for confining the fovea and exudates. The differentiation among OD and other region is higher in green channel picture; in this way the grayscale picture of green channel is utilized for OD determination. In order to find the OD candidates a threshold value is determined by using the estimated pixel count of OD [20].

$$Estimated\ OD\ pixel\ count\ = \frac{\pi * (\mathrm{D}/2)^2}{8 * 7.33} \tag{3}$$

Then the area and density conditions are employed to scrutinize the selected region and the presence of vessel used to decide the OD region. Figure.4 depicts the output of various stages of this process.

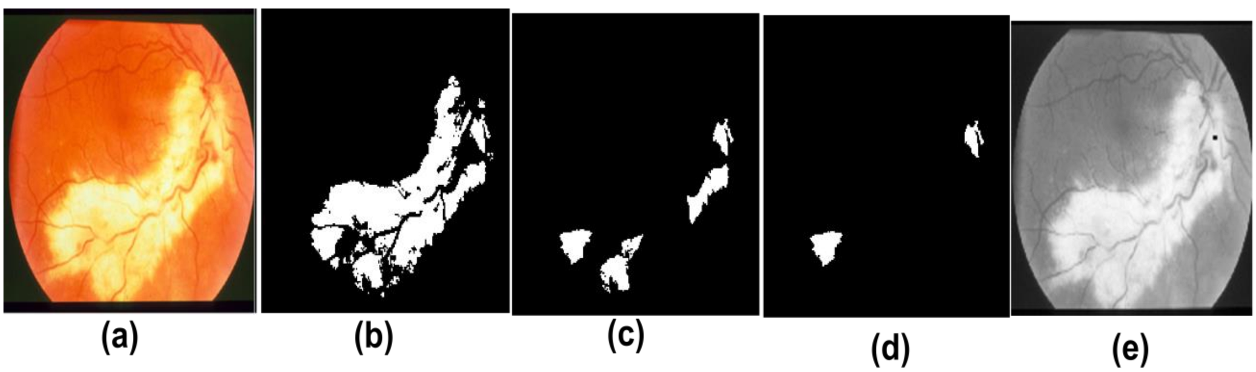

Figure. 4. Localization of Optic Disc
(a) Color fundus image (b) Threshold image with initial OD applicants (c) OD applicants after area criterion
(d) OD applicants after density criterion (e) Image with OD location

3.3 Fovea localization

The presence of exudates in the fovea region is considers as CSME; therefore localizing fovea is important for the grading of macular edema [21,22]. The fovea region is enhanced by employing morphological operations. The blood vessel and hemorrhages are very similar to fovea that is suppressed by applying suitable opening and closing operations. The opening and closing operators are constructed by using the basic operators such as Erosion and Dilation.

$$g(x) = E \rightarrow T \tag{4}$$

Where,
g – gray scale image
x – the pixel position,
and T in the range of 0 to 255.

$$Dilation: \ [\delta_B(g)](x) = \max_{b \epsilon B(x)} g(x+b) \tag{5}$$

$$Erosion: \; [\varepsilon_B(g)](x) = \min_{b \epsilon B(x)} g(x+b) \qquad (6)$$

Where, B is the structuring element, which decides gives the size of the shape.

The similar regions other than fovea are removed by opening and closing operators.

$$Closing: g_{closing} = \phi_B = \varepsilon_B[\,\delta_B(g)] \qquad (7)$$

$$Opening: g_{opening} = \gamma_B = \delta_B[\,\varepsilon_B(g_{closing})] \qquad (8)$$

The structuring element B gives the size of the operator. In this work the size 30 and shape disk is assigned for B. After the morphological activity, the underlying fovea applicants are chosen and advanced dependent on the system talked about in segment 3.2. At that point, the distance condition is employed for further advancement. In general the distance between OD and fovea range from 1.84 DD to 4.2DD [23,24]. The selected region within this distance only selected for further process. In the last stage, the region with lesser vessel pixel is finalized as fovea area. Figure.5 shows the consequence of fovea confinement.

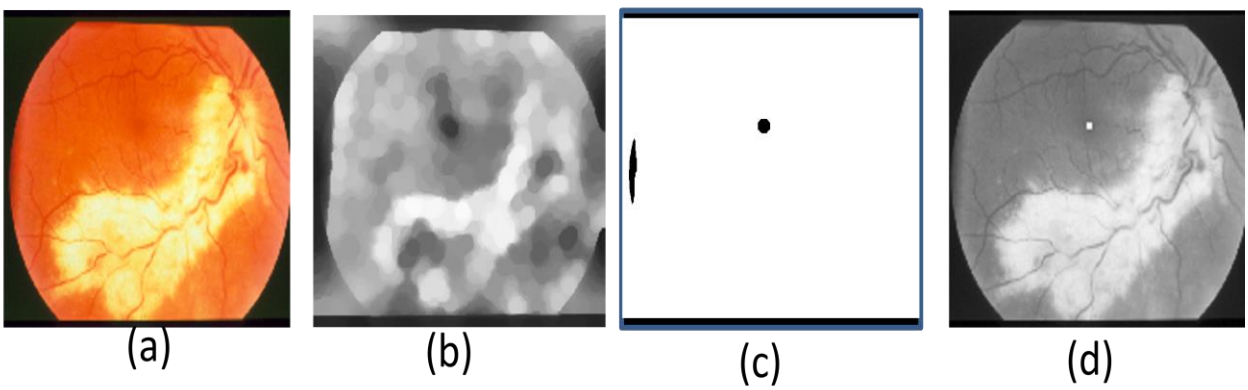

Figure.5. Image shows the fovea confinement

(a) Color fundus image (b) Image after morphological operations (c) Threshold image with fovea candidates (d) Image with fovea location

3.4 Exudates detection and grading of maculae edema

Thresholding technique is simple and effective for initial segmentation in image processing. Among various thresholding techniques the Otsu is the most popular for grayscale image segmentation [26]. In this work, the exudates candidates are extracted using Otsu based thresholding technique. The threshold value is calculated in 2D gray scale image and that value is used to extract the exudates candidates from gray scale image of the green band. Figure 6.(e) shows the extracted exudates candidate by the Otsu thresholding.

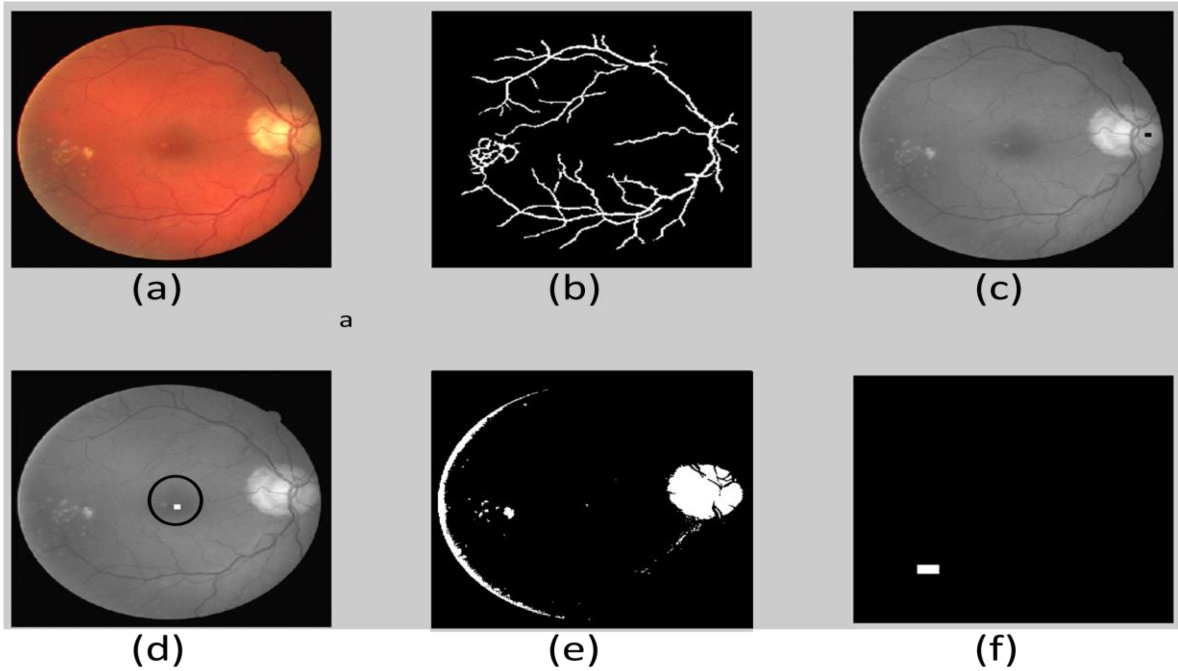

Figure.6. Detection of macular edema
(a) Color fundus image (b) vessel segmented image (c) Image with OD location
(d) Image with fovea location (e) Exudates candidates (f) Superimposed B/W Fovea region

4. Results and Discussions

The methodology was executed on 3.06 GHz community i3 processor with 3.17 GB RAM using MATLAB 7.6. The proposed system gained a ground movement of 100% (i.e., the macular edema was distinguished precisely in 40 out of the 40 pictures contained in the DRIVE dataset. Figure.7 shows the got aftereffects of the proposed technique on DRIVE collection. The reviewing of macular edema is finished by inspect the presence of exudates on the retinal area.

1) The exudates present on the fovea region graded as CSME.
2) The exudates present but not in fovea region graded as non-CSME.
3) The exudates does not present on the image graded as healthy.

In despite the presence of dim hemorrhages or bright OD, the consequences of the proposed technique are good and it shows the adequacy of the proposed strategy for reviewing the macular edema.

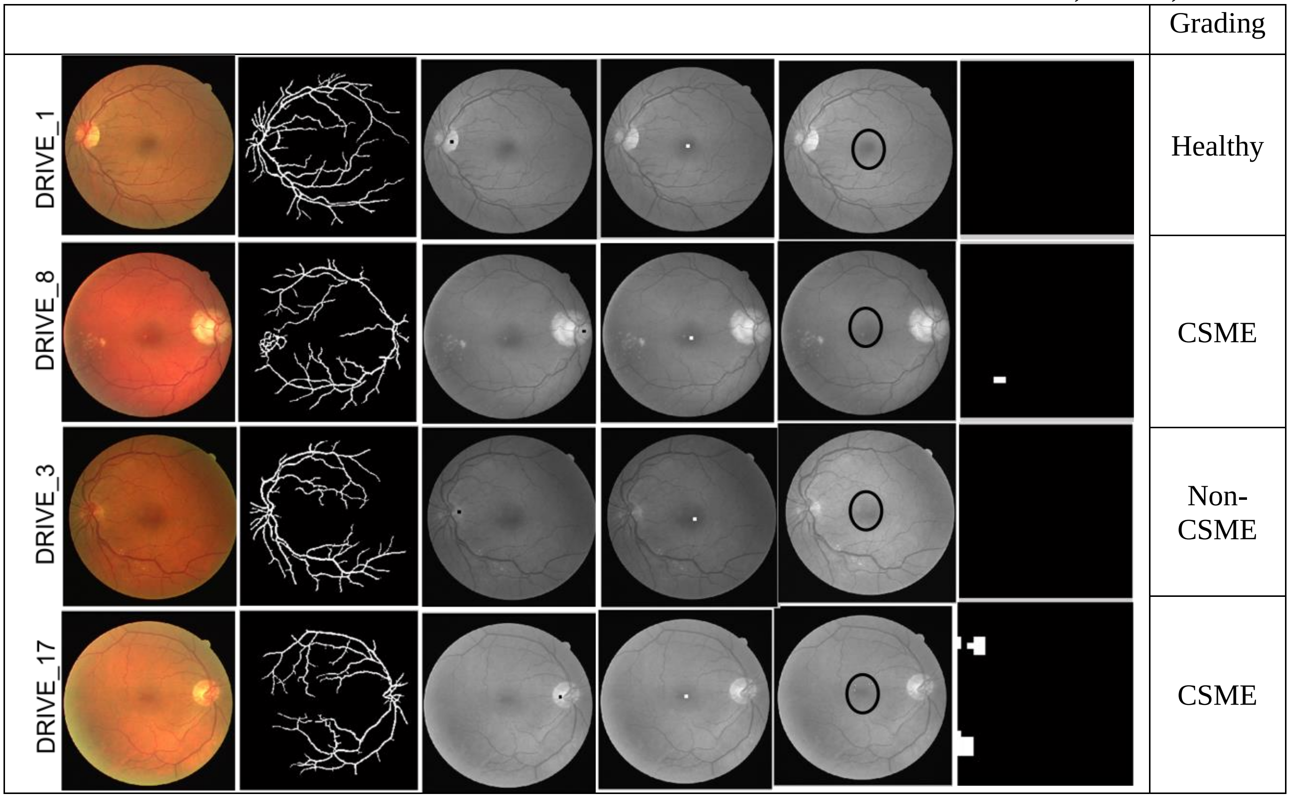

Figure.7. Grading of macular edema
(a)Color fundus image (b) vessel segmented image (c) Image with OD location
(d) Image with fovea location (e) the estimated Fovea region (f) the superimposed Fovea region (B/W)

5. Conclusion

Diabetic macular edema is one of the retinal abnormalities that can lead to irreversible vision loss. In this work, a fully automated method is proposed for grading of diabetic macular edema. The main contribution of the proposed system is localizing the anatomical features and exudates detection. A huge decrease in calculation time and the evaluating of macular edema even in neurotic or low quality pictures are the most significant upgrades of this work. in spite of better execution time, the proposed approach doesn't have any boundaries to be tuned relying upon datasets. The test results show our framework beats the test of the DME evaluating and exhibit a promising adequacy.

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